

# OCO-2 Absorption Cross sections

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Feb. 2012

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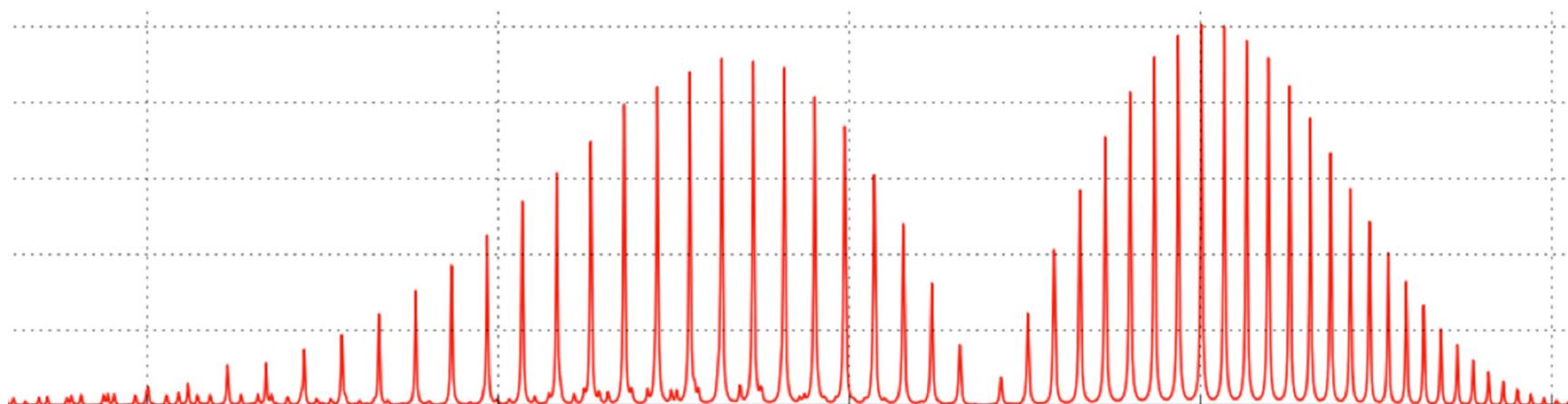
2

OCO-2 ABSCO Overview

1

# Agenda

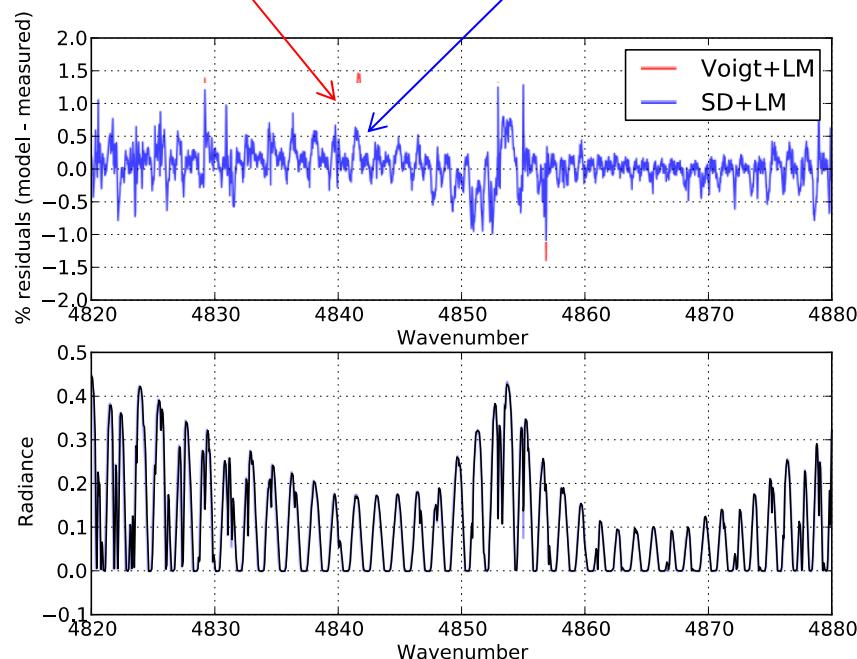
1. Review v4.0 line models (latest revision)
2. Current challenges for O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O



# ABSCO v4.0 review: new CO<sub>2</sub> models, 1.6μm and 2μm residuals

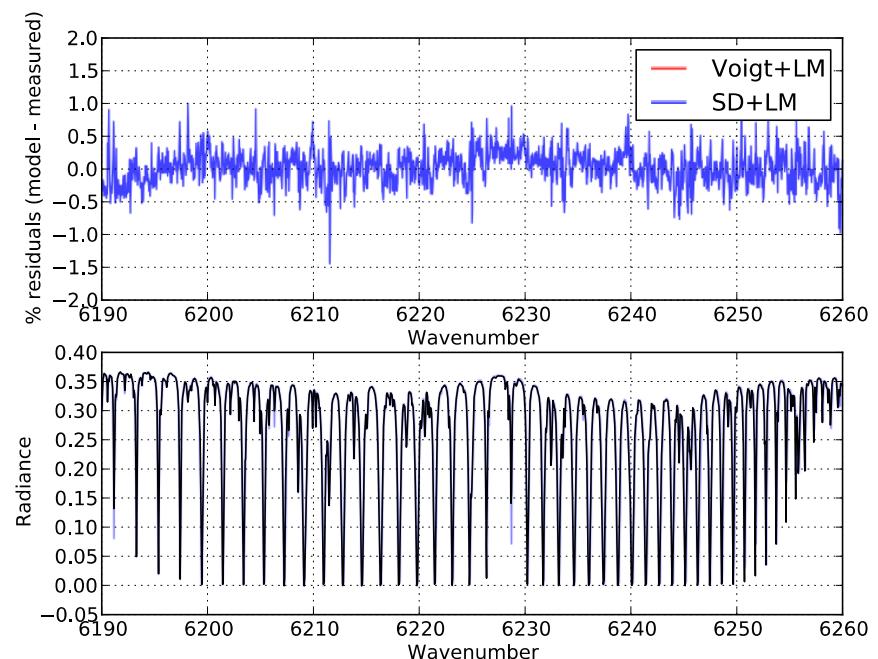
## State of the art

Lamouroux et al 2010, Voigt shapes (HITRAN 2012?)



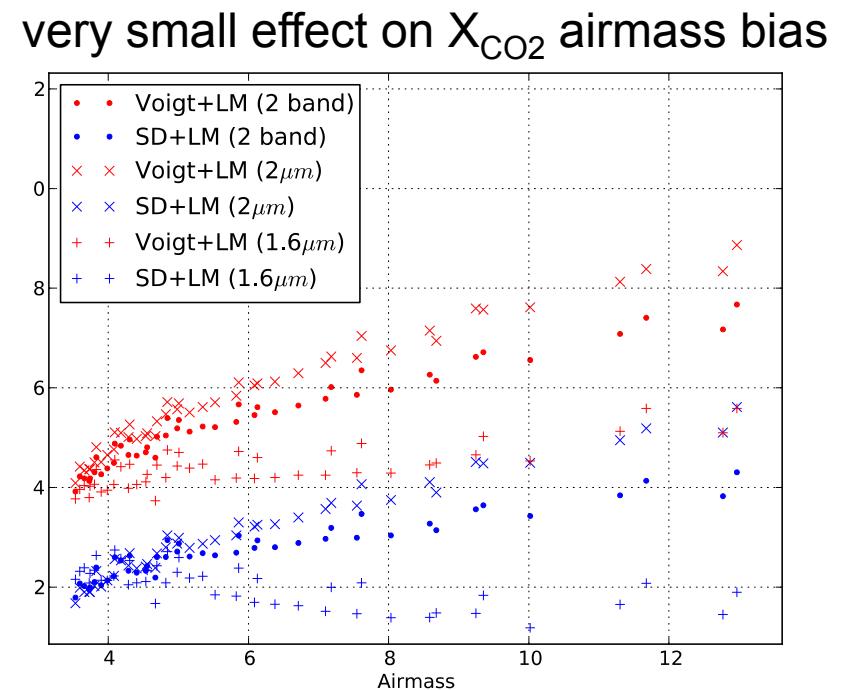
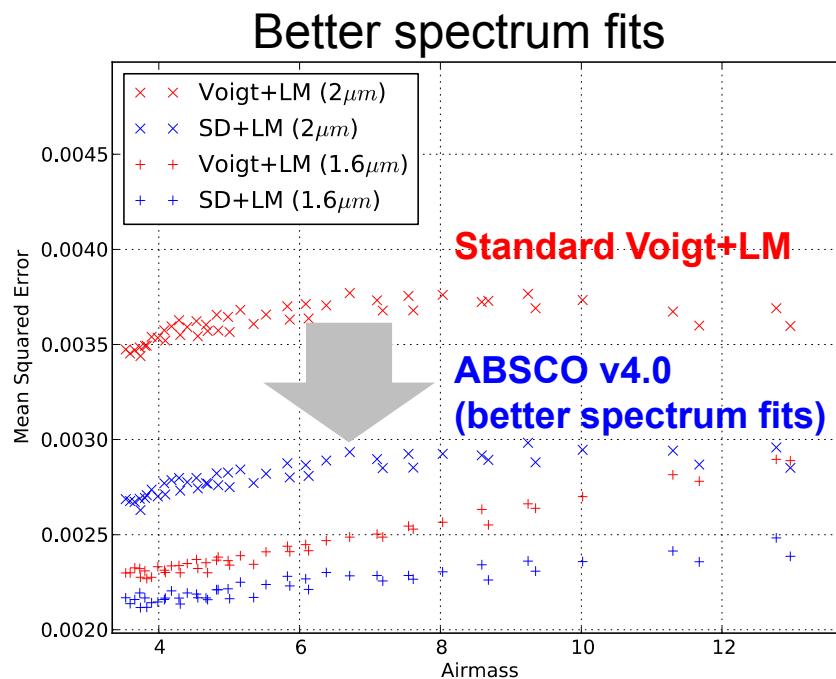
## ABSCO v4.0

Nearest-neighbor line mixing  
Speed dependent profile



TCCON retrieval for Park Falls 22 Dec. 2004, airmass ~12

# ABSCO v4.0 review: CO<sub>2</sub> models

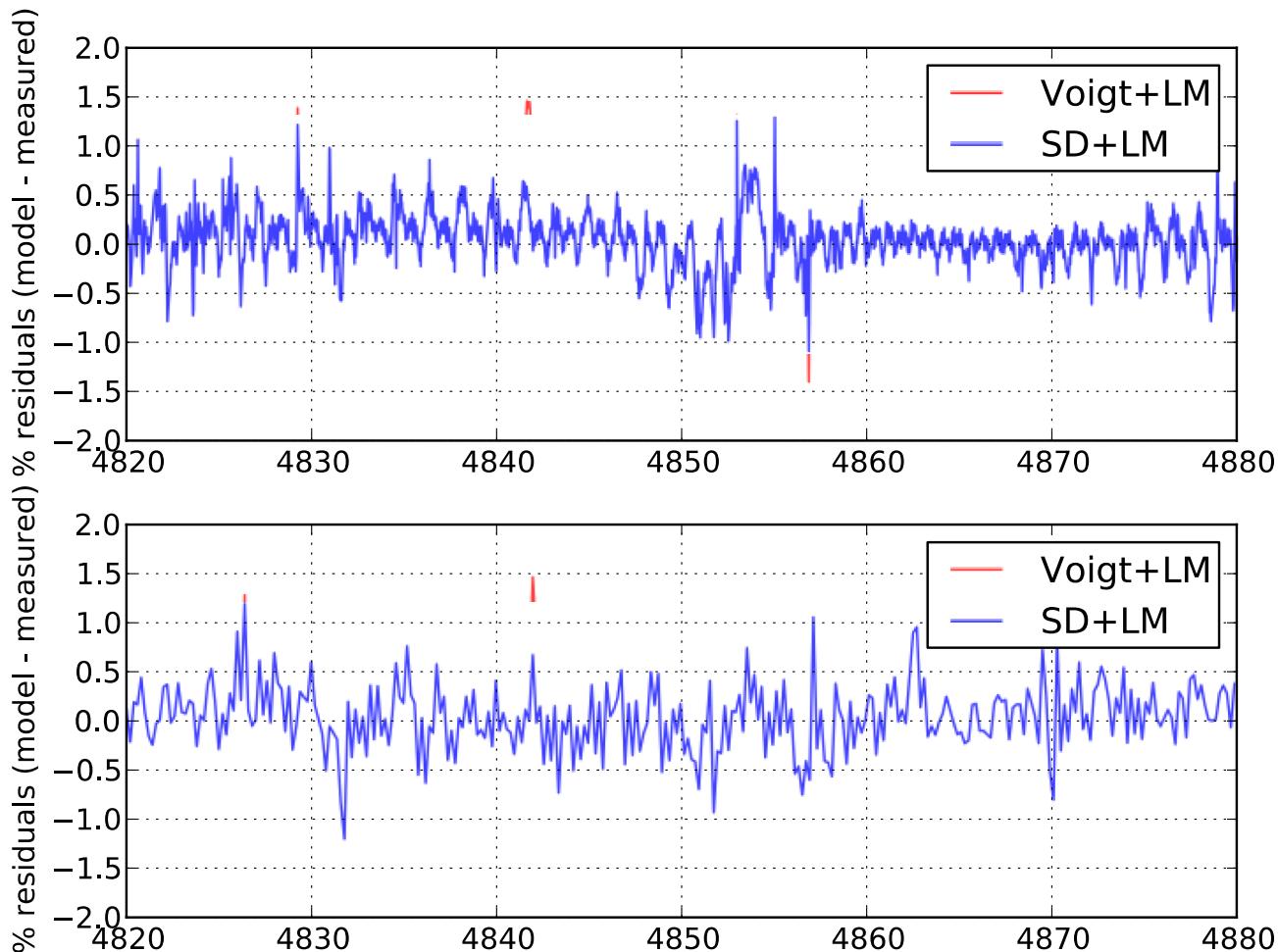


TCCON retrieval for Park Falls 22 Dec. 2004

X<sub>CO<sub>2</sub></sub> Slope

V+LM	V4.0	V+LM	V4.0	V+LM	V4.0
0.355	0.219	0.468	0.376	0.131	-0.101

# ABSCO v4.0 review: Similar effect for TCCON and GOSAT

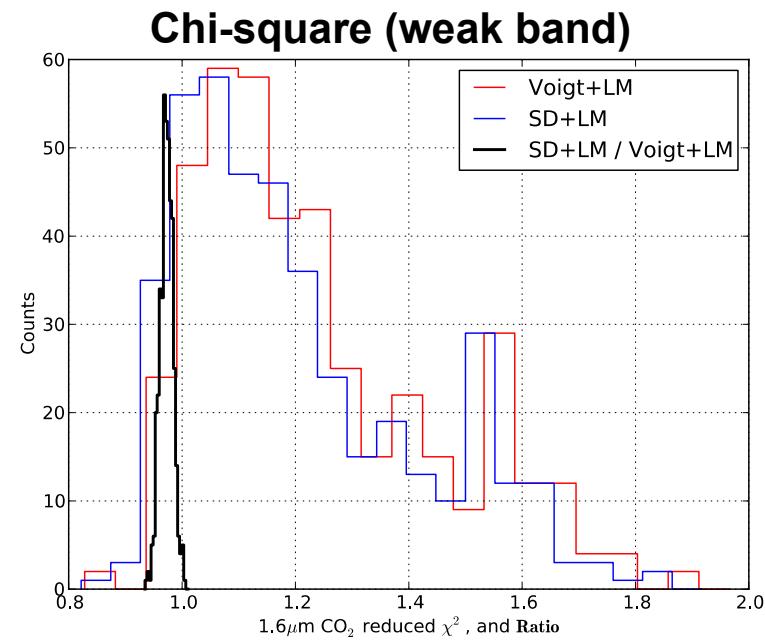
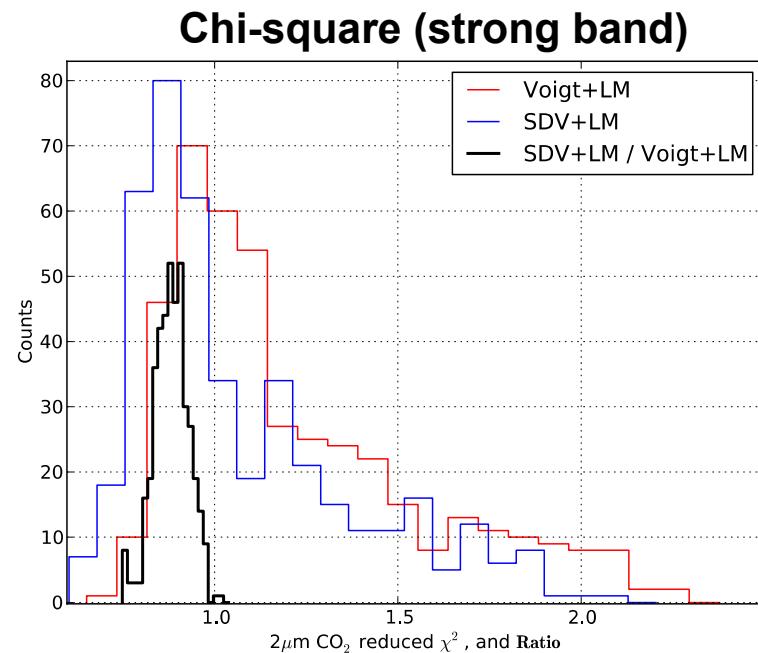


TCCON  
retrieval for  
Park Falls 22  
Dec. 2004

GOSAT Science  
Acceptance Test,  
mean of ~300  
soundings

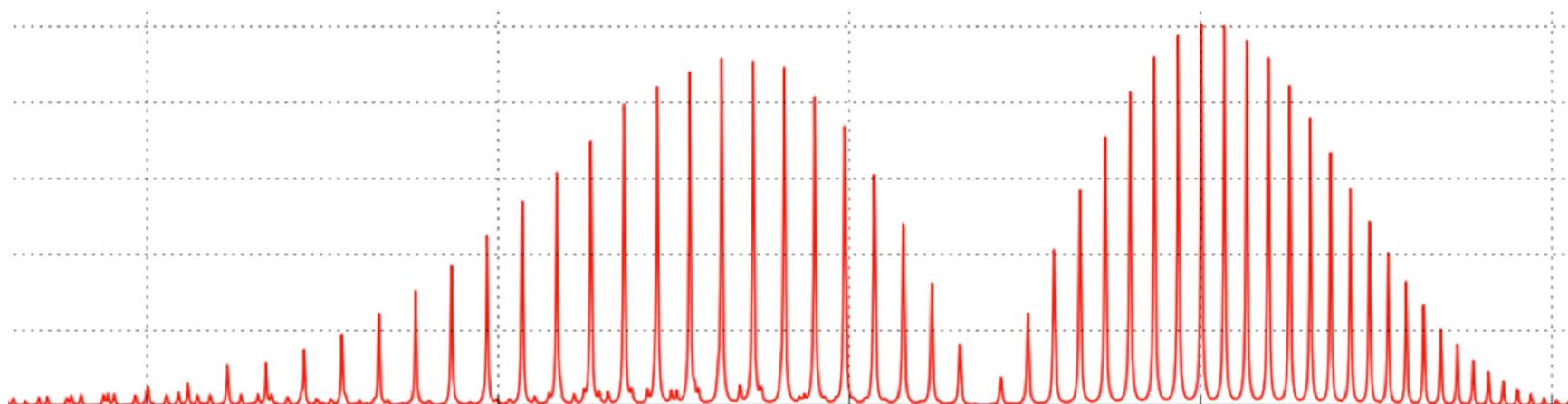
# ABSCO v4.0 review: GOSAT retrievals over TCCON stations

# Converged		Scatter v. TCCON		Correlation	
V+LM	V4.0	V+LM	V4.0	V+LM	V4.0
279 (65.6%)	300 (70.6%)	1.50 ppm	1.39 ppm	0.767	0.781



# Agenda

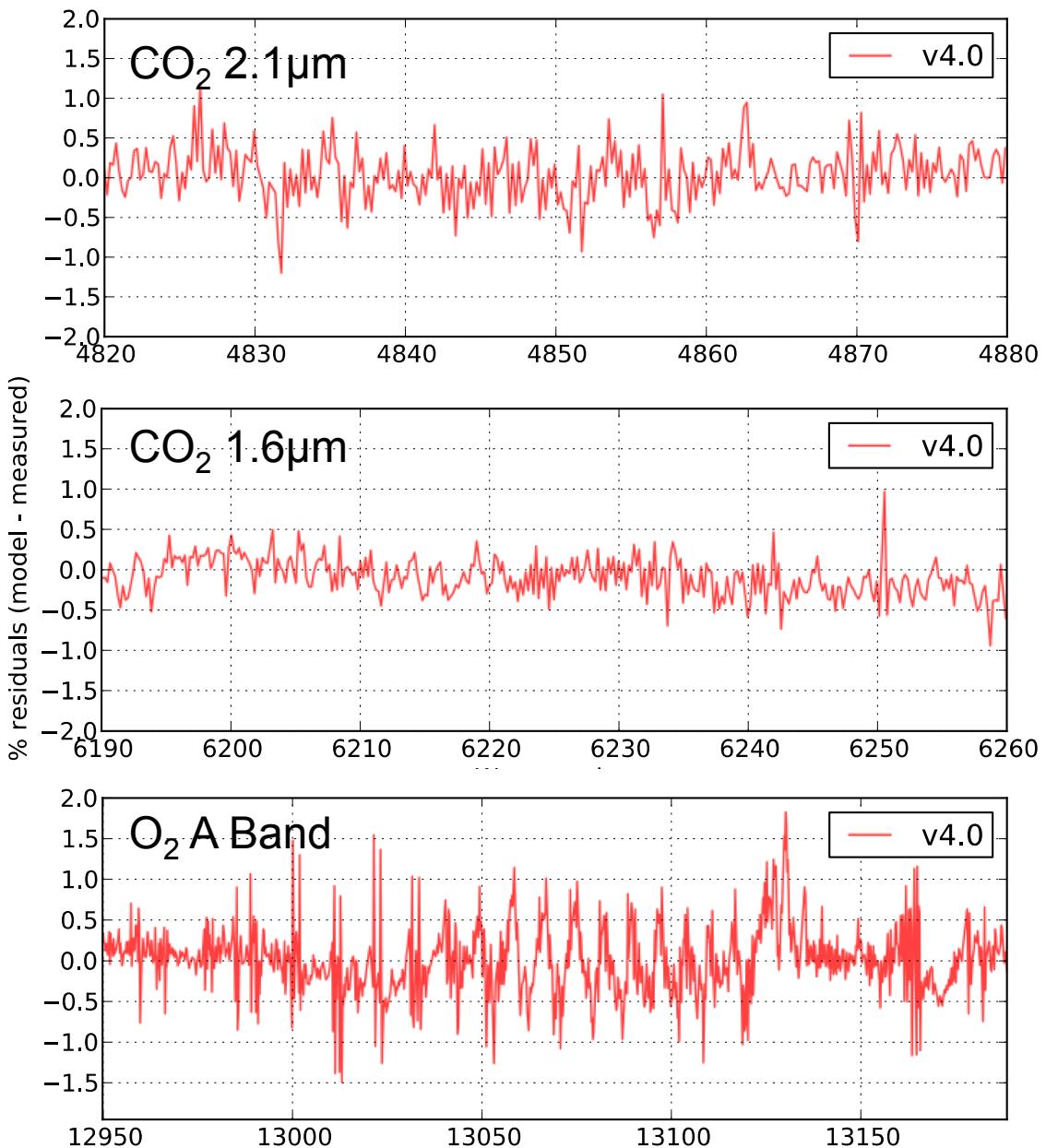
1. Review v4.0 line models (latest revision)
2. Current challenges for O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O



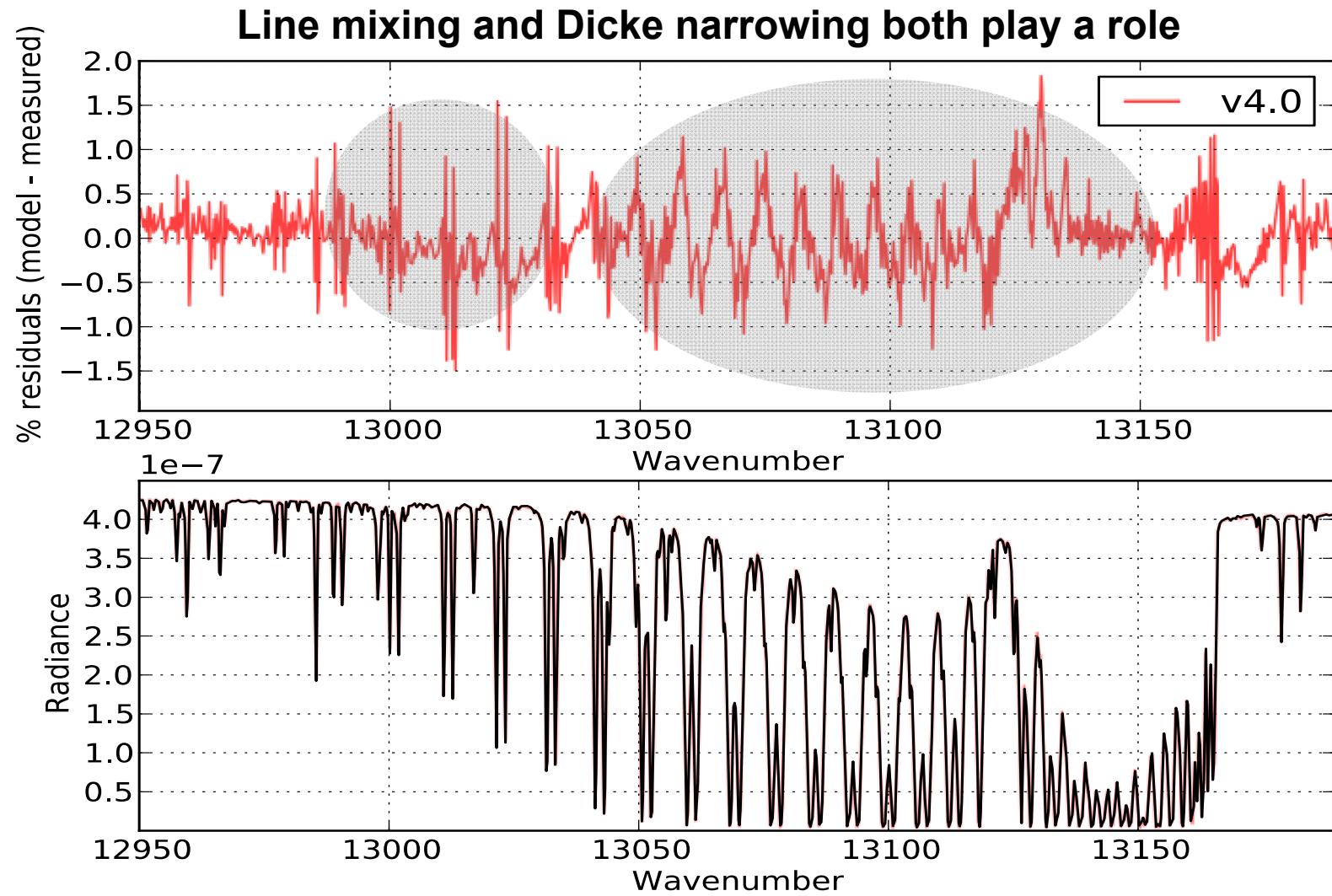
# Current challenges

10hPa bias in surface pressure

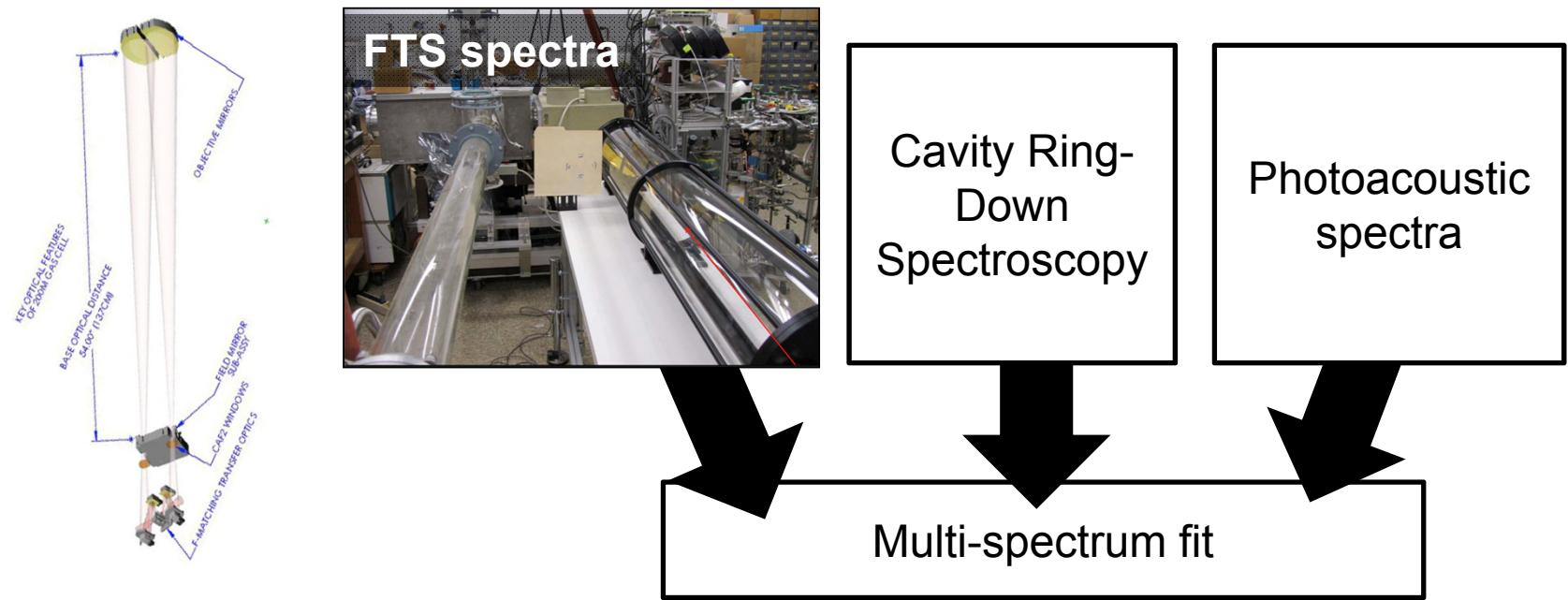
Airmass bias in single-band CO<sub>2</sub> retrievals  
(especially in the 2.1μm band)



# Current challenges: The A Band

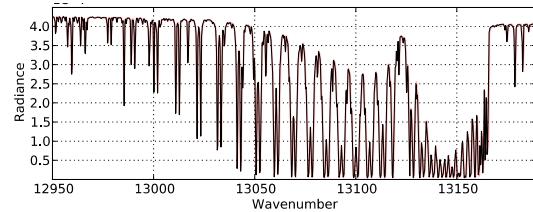


# New O<sub>2</sub> A Band measurements



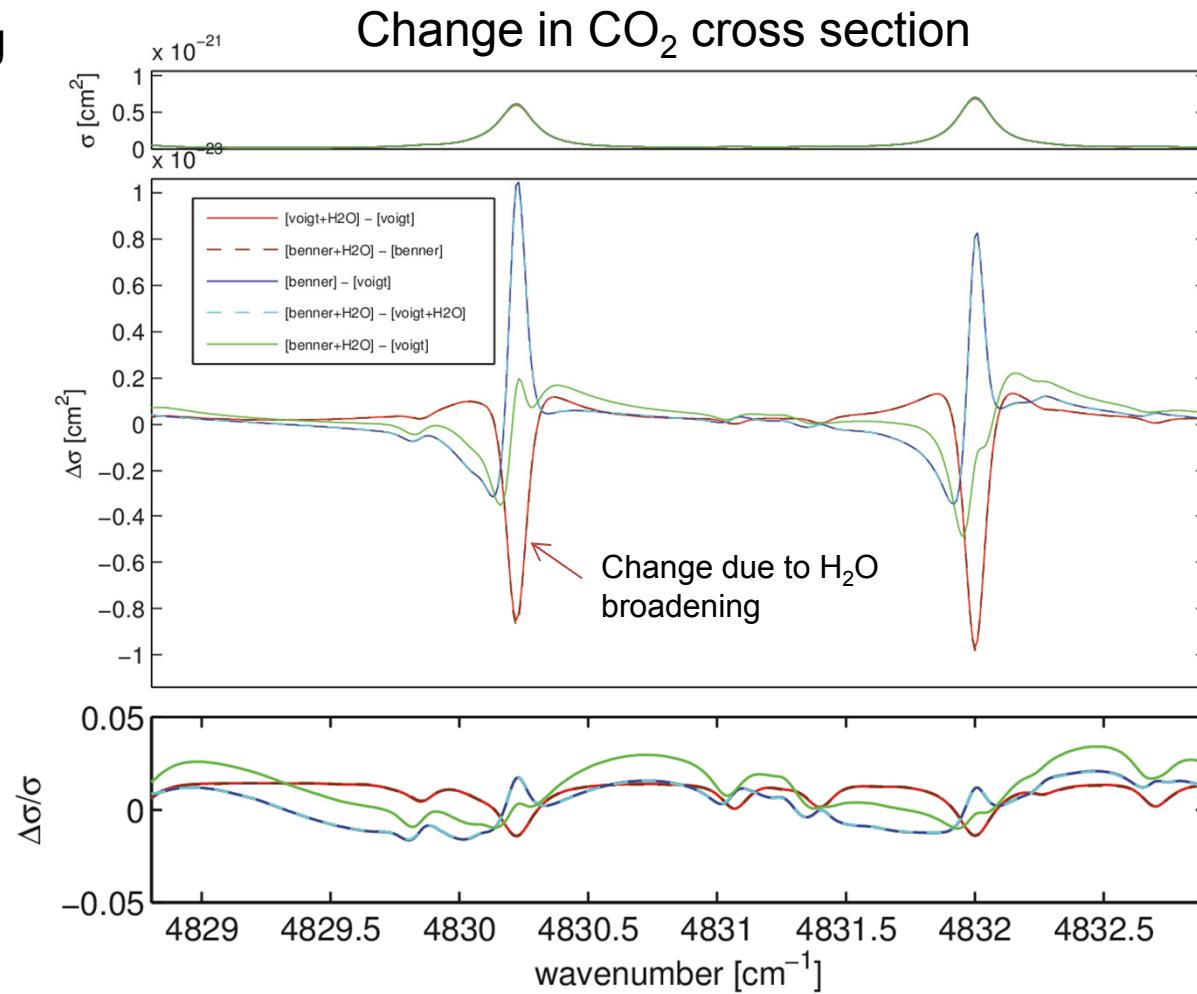
Revised model incorporating:

- Line mixing
- Narrowed line shapes (Rautian, Galatry, etc. – the best one is still unknown).
- Collision-Induced Absorption (CIA)



# Current challenges: H<sub>2</sub>O broadening

H<sub>2</sub>O broadening [Sung 2009] as significant as other strong band width effects like line mixing, speed dependence, etc.



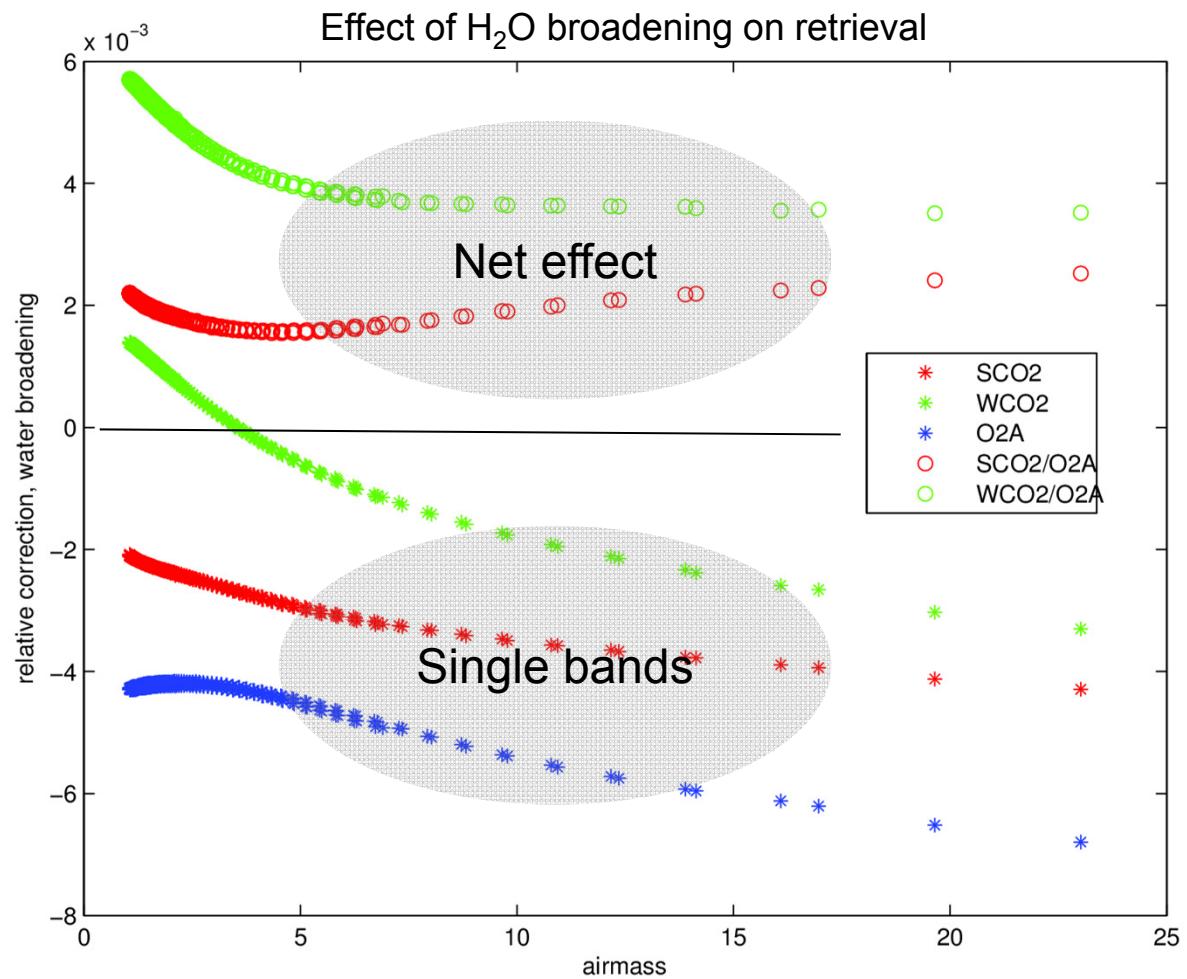
# Current challenges: $\text{H}_2\text{O}$ broadening

Influence on  $X_{\text{CO}_2}$  could be 0.2-0.5%

Must account for broadening of both  $\text{O}_2$  and  $\text{CO}_2$

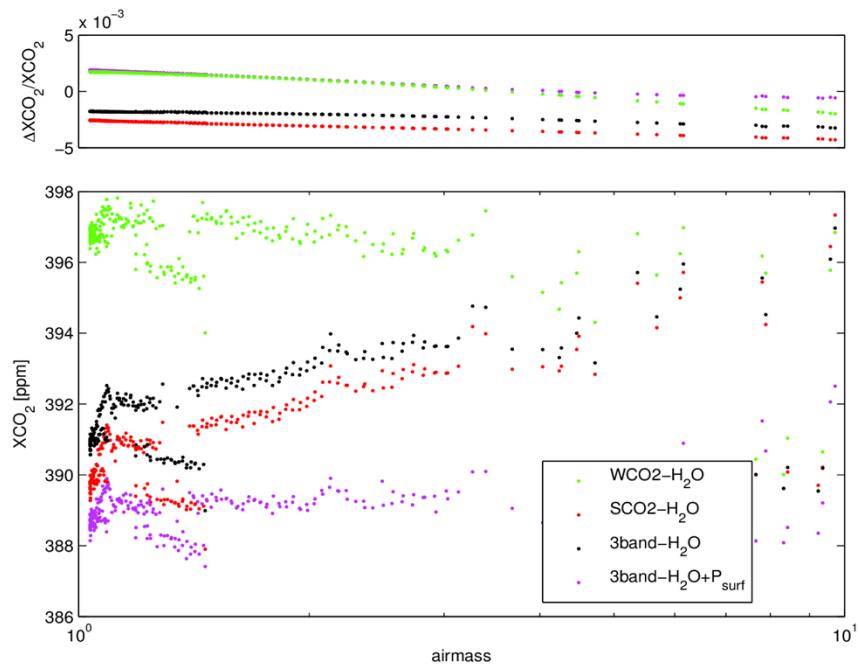
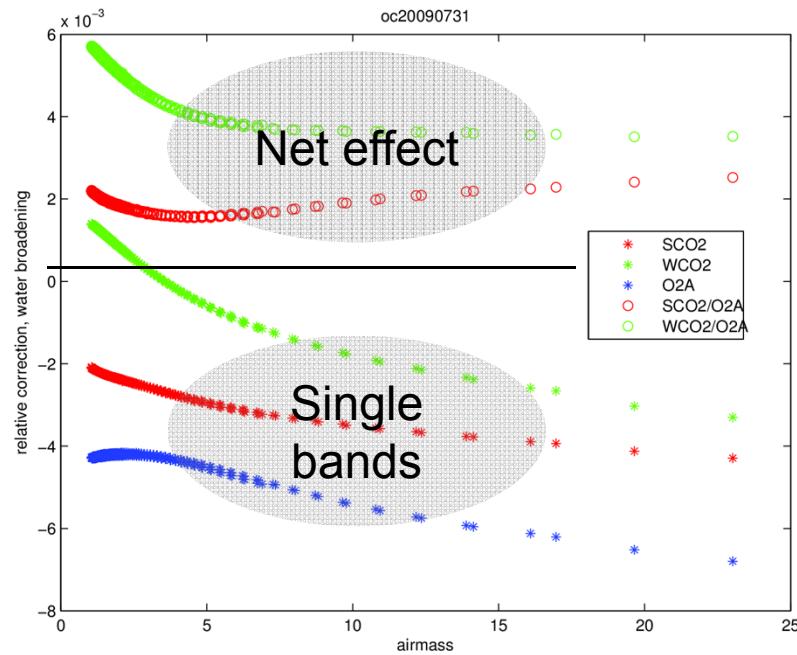
- Broadening of  $\text{CO}_2$  by  $\text{H}_2\text{O}$  is available [Sung et al. 2009].
- Broadening of  $\text{O}_2$  less certain, but we must consider it

Stronger influence on  $\text{O}_2$  effectively enhances  $X_{\text{CO}_2}$



Courtesy Fabiano Oyafuso

# Current challenges: H<sub>2</sub>O broadening



Courtesy Fabiano Oyafuso, JPL

Water broadening of O<sub>2</sub> (Fanjoux) and CO<sub>2</sub> (Devi) now implemented in abscosco

- Single band results agree with previous implementation in GFIT.
- Magnitude of effect can be as large as a few tenths of a percent.
- Caveat: residuals are still dominated by other spectroscopic effects.

# $\text{H}_2\text{O}$ broadening of $\text{CO}_2$

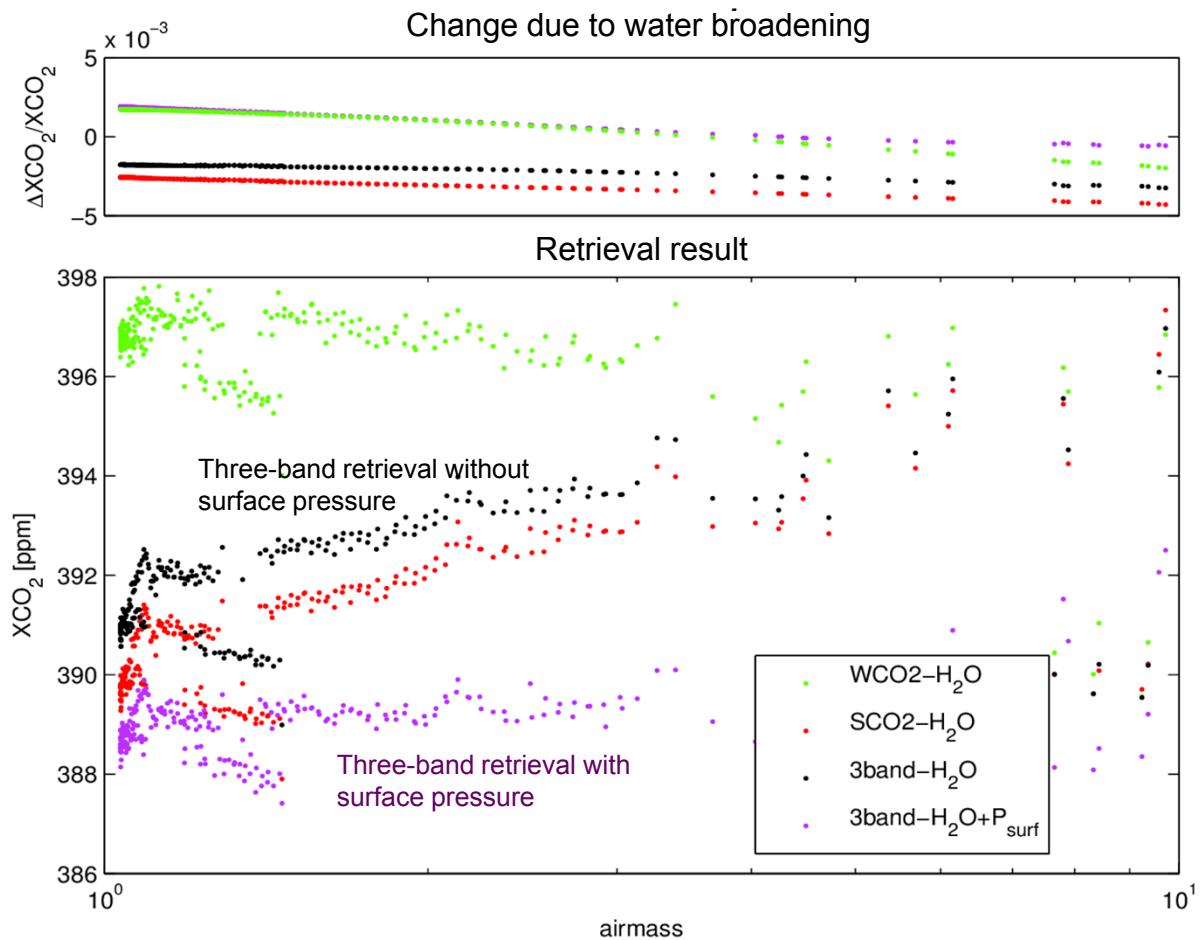
Water broadening now implemented

- $\text{O}_2$  from Fanjoux
- $\text{CO}_2$  from [Sung 2009]

Single band results agree with an implementation in GFIT.

Changes  $X_{\text{CO}_2}$  by up to ~0.4%, though residuals still dominated by other spectroscopic effects.

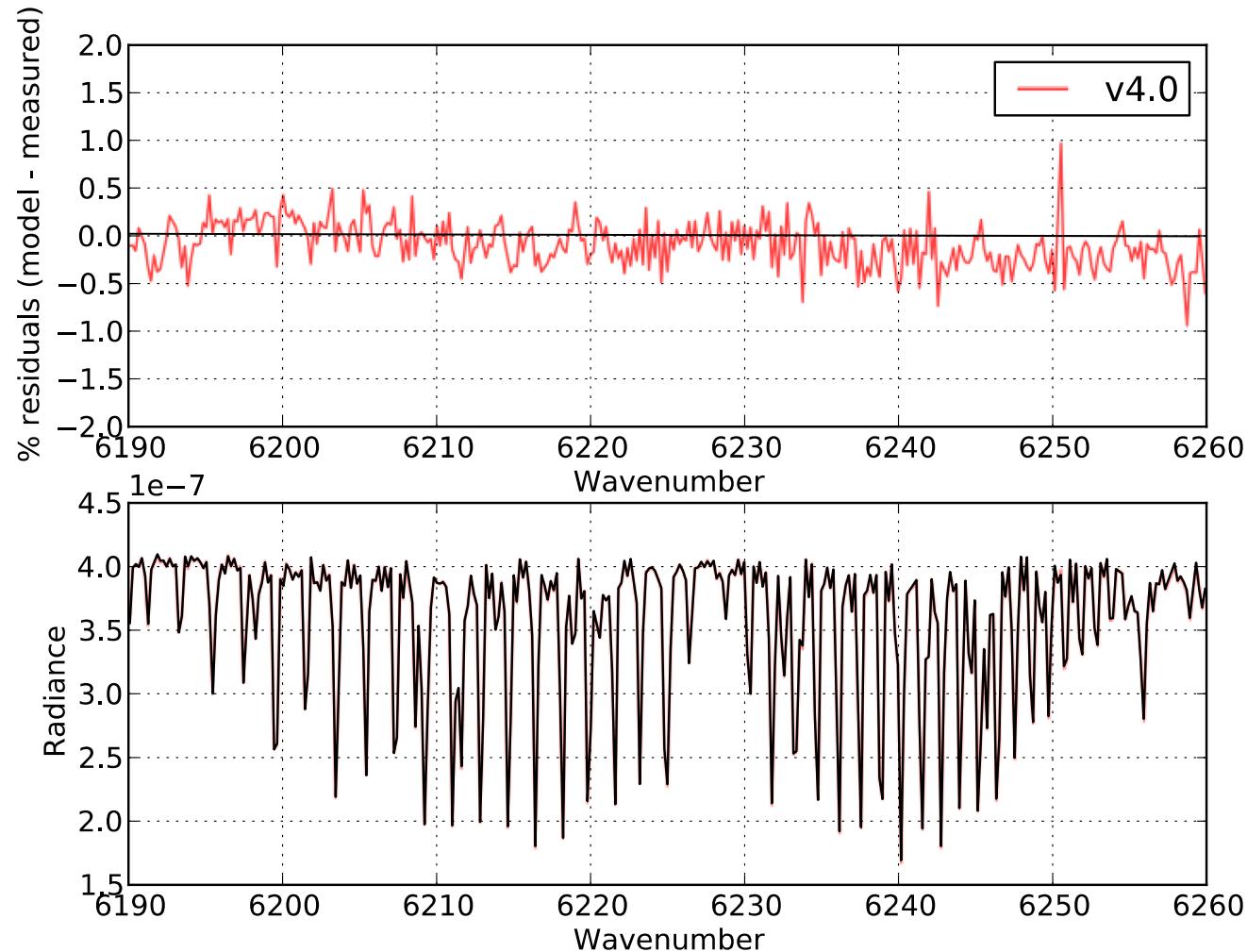
For L2, start with linear interpolation for the VMR interval from 0 to 5%?



Courtesy Fabiano Oyafuso

# Current challenges: WCO<sub>2</sub> continuum

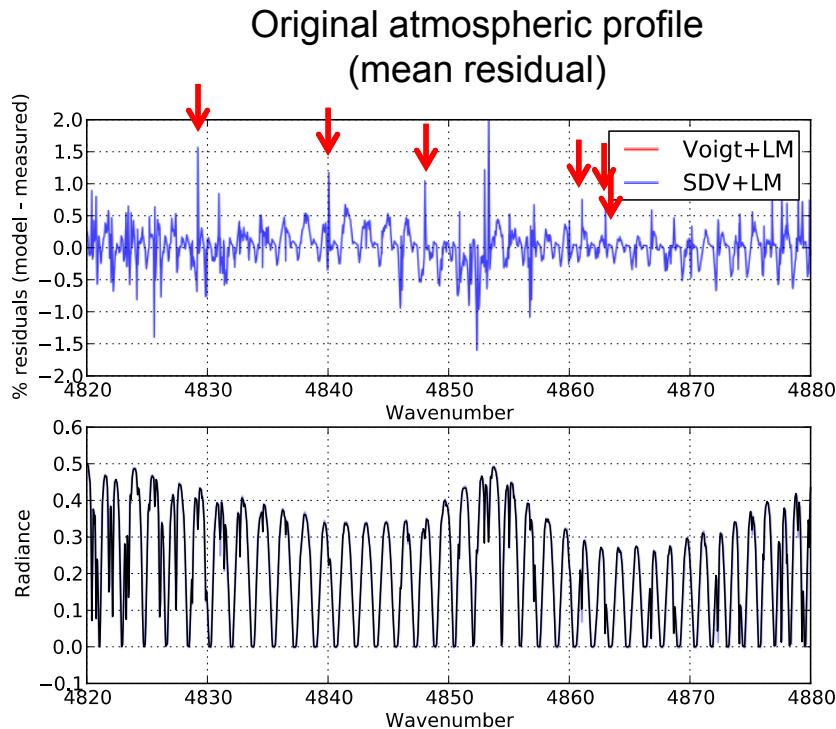
Natural variations in continuum or very weak CIA from CO<sub>2</sub> absorption?



# Current challenges: H<sub>2</sub>O profiles

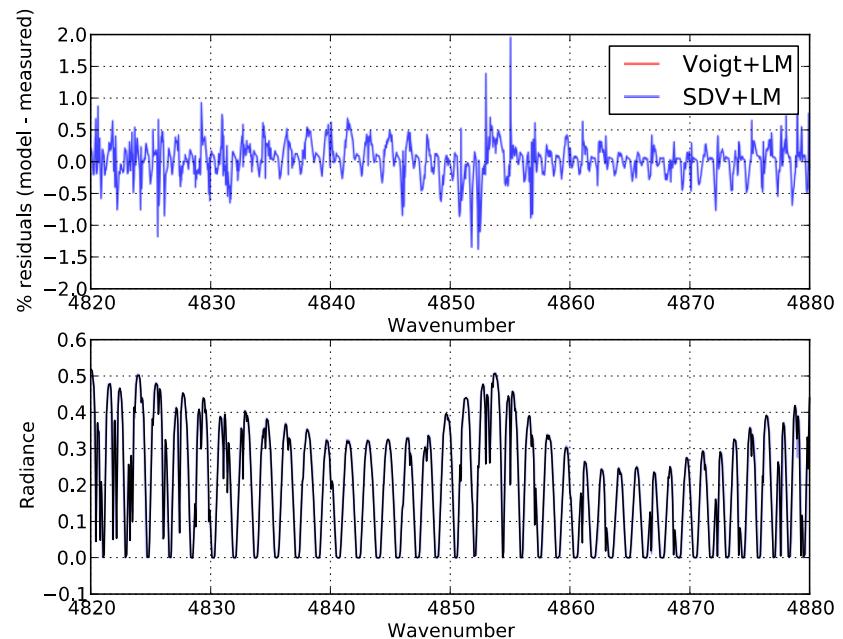
TCCON residuals evidence high sensitivity to atmospheric water profiles.  
Ad hoc fixes work, but only on a single case...

## BEFORE

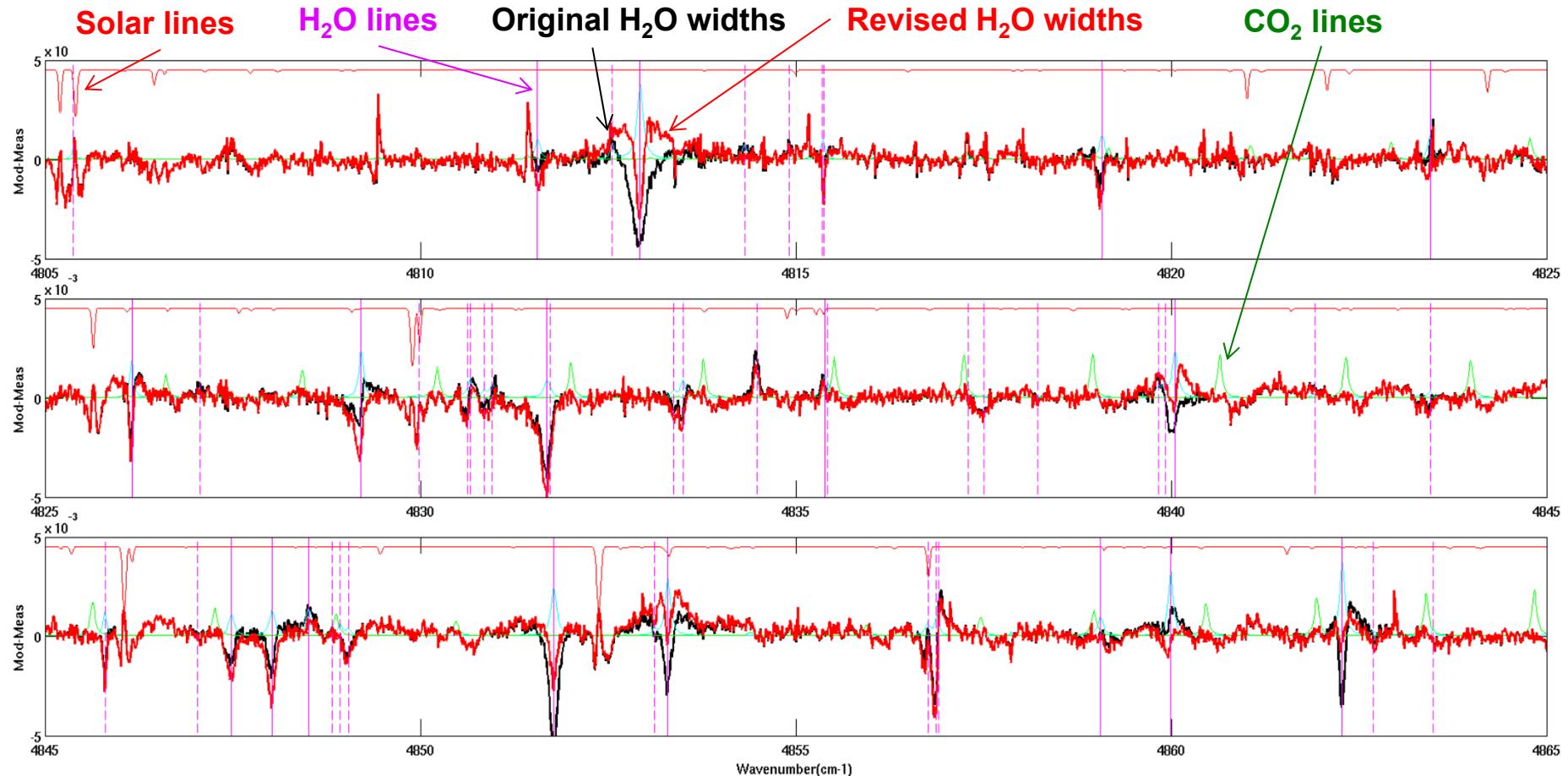


## AFTER

Reduced tropospheric H<sub>2</sub>O by 10x  
(mean residual, modified atmosphere)



# Current challenges: H<sub>2</sub>O parameters



Courtesy Yibo Jiang, Linda R. Brown

# Current challenges: H<sub>2</sub>O parameters

We have two sets of intensity **measurements (a,b)** and a theoretical **calculation (c)**

**Set b and calc.** match with **precisions of 1% to 2%**, and **mean offsets of 5%**

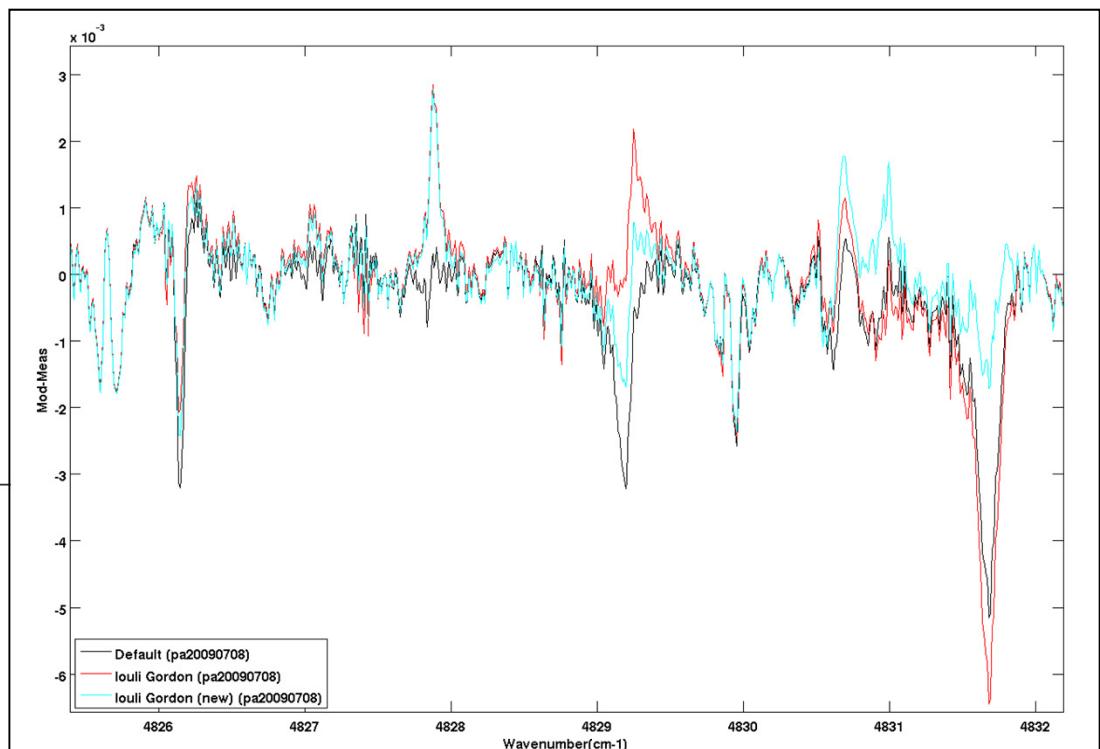
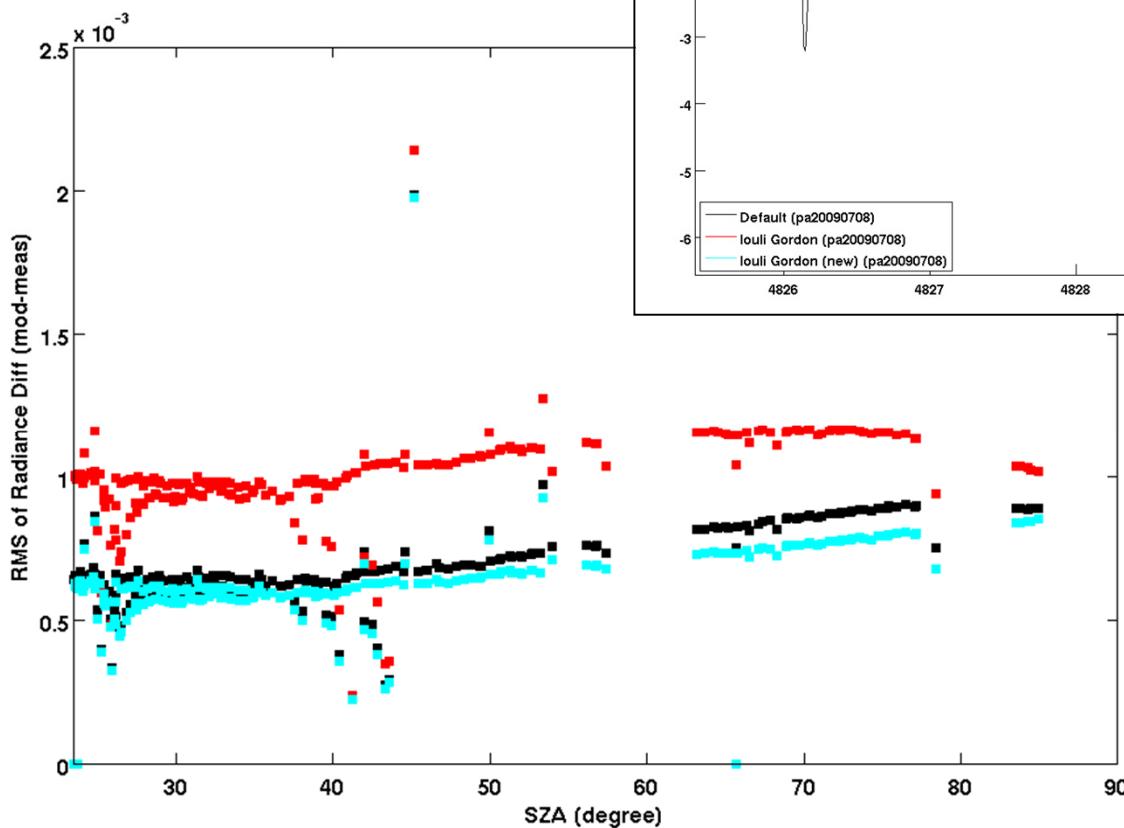
To make a choice based on *atmospheric data*, we need to look at *the assumed temperature profiles because the range of ground state energies is big!*



nu cm-1	unc	obs	int	a %unc`	band J'Ka'Kc'				J"Ka"Kc"	Obs	Intb	%u	a/b	int c	c/b	G.S.		
					T	030	7	2	5									
4800.9961	1	0.990E-24	1	T	030	7	2	5	000	7	1	6	0.101E-23	4	0.98	11 4800.996000 9.790E-25	0.97	704.
4811.5614	1	0.128E-23	1	T	030	5	2	4	000	5	1	5	0.133E-23	2	0.96	11 4811.562400 1.271E-24	0.93	326.
4812.9277	1	0.546E-23	1	S	030	2	2	1	000	1	1	0	0.601E-23	1	0.91	?11 4812.927610 5.735E-24	0.95	42.3
4819.0781	1	0.185E-23	1	T	030	2	2	0	000	1	1	1	0.196E-23	1	0.94	?11 4819.078340 1.859E-24	0.95	37.1
4823.4534	1	0.125E-23	1	T	030	7	1	6	000	7	0	7	0.127E-23	2	0.98	11 4823.454280 1.225E-24	0.96	586.
4829.2118	1	0.242E-23	1	T	030	6	2	5	000	6	1	6	0.262E-23	1	0.92	?11 4829.211870 2.468E-24	0.94	447.
4831.6873	1	0.120E-23	1	T	030	3	2	2	000	2	1	1	0.120E-23	2	1.00	11 4831.686010 1.158E-24	0.97	95.1
4840.0525	3	0.275E-23	5	S	030	5	3	2	000	5	2	3	0.299E-23	1	0.92	?11 4840.052280 2.852E-24	0.95	446.
4847.4847	1	0.136E-23	1	T	030	4	3	1	000	4	2	2	0.136E-23	2	1.00	11 4847.484040 1.323E-24	0.97	315.
4848.0259	1	0.178E-23	1	T	030	4	2	3	000	3	1	2	0.184E-23	2	0.97	11 4848.025520 1.765E-24	0.96	173.3
4851.7750	2	0.321E-23	3	S	030	3	2	1	000	2	1	2	0.350E-23	1	0.92	?11 4851.775130 3.264E-24	0.93	79.4
4853.2972	2	0.356E-23	3	S	030	3	3	0	000	3	2	1	0.397E-23	1	0.90	?11 4853.297080 3.800E-24	0.96	212.1
4859.0605	1	0.135E-23	1	T	030	3	3	1	000	3	2	2	0.144E-23	2	0.94	?11 4859.060020 1.351E-24	0.94	206.3
4862.2795	2	0.439E-23	3	S	030	4	3	2	000	4	2	3	0.480E-23	1	0.91	?11 4862.279390 4.560E-24	0.95	300.3
4867.9887	1	0.120E-23	1	T	030	5	3	3	000	5	2	4	0.123E-23	2	0.98	11 4867.989100 1.181E-24	0.96	416.
4876.7821	1	0.222E-23	1	T	030	6	3	4	000	6	2	5	0.234E-23	1	0.95	11 4876.782700 2.227E-24	0.95	552.
4835.3913	1	0.113E-23	1	T	110	8	2	7	000	9	3	6	0.110E-23	2	1.03	11 4835.391040 1.045E-24	0.95	982.
4890.3188	1	0.222E-23	1	T	110	8	3	6	000	9	4	5	0.234E-23	1	0.95	11 4890.319180 2.228E-24	0.95	1360.
4891.8997	2	0.349E-23	3	S	110	6	1	6	000	7	2	5	0.376E-23	2	0.93	?11 4891.899550 3.589E-24	0.95	782.
4894.7692	1	0.128E-23	1	T	110	7	2	6	000	8	3	5	0.130E-23	3	0.98	11 4894.769660 1.243E-24	0.95	1050.
4826.1664	1	0.116E-23	1	T	011	9	2	8	000	10	4	7	0.116E-23	1	1.00	11 4826.167670 1.115E-24	0.96	1581.
4848.5079	1	0.109E-23	1	T	011	8	4	4	000	9	6	3	0.109E-23	1	1.00	11 4848.509250 1.041E-24	0.96	1631.
4859.9978	2	0.287E-23	3	S	011	8	0	8	000	9	2	7	0.299E-23	1	0.96	11 4859.997680 2.840E-24	0.95	1201.
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4874.2771	1	0.124E-23	1	T	011	8	2	7	000	9	4	6	0.127E-23	2	0.98	11 4874.277670 1.206E-24	0.95	1340.
4893.1417	2	0.272E-23	3	S	011	6	4	2	000	7	6	1	0.290E-23	1	0.94	?11 4893.141640 2.762E-24	0.95	1216.

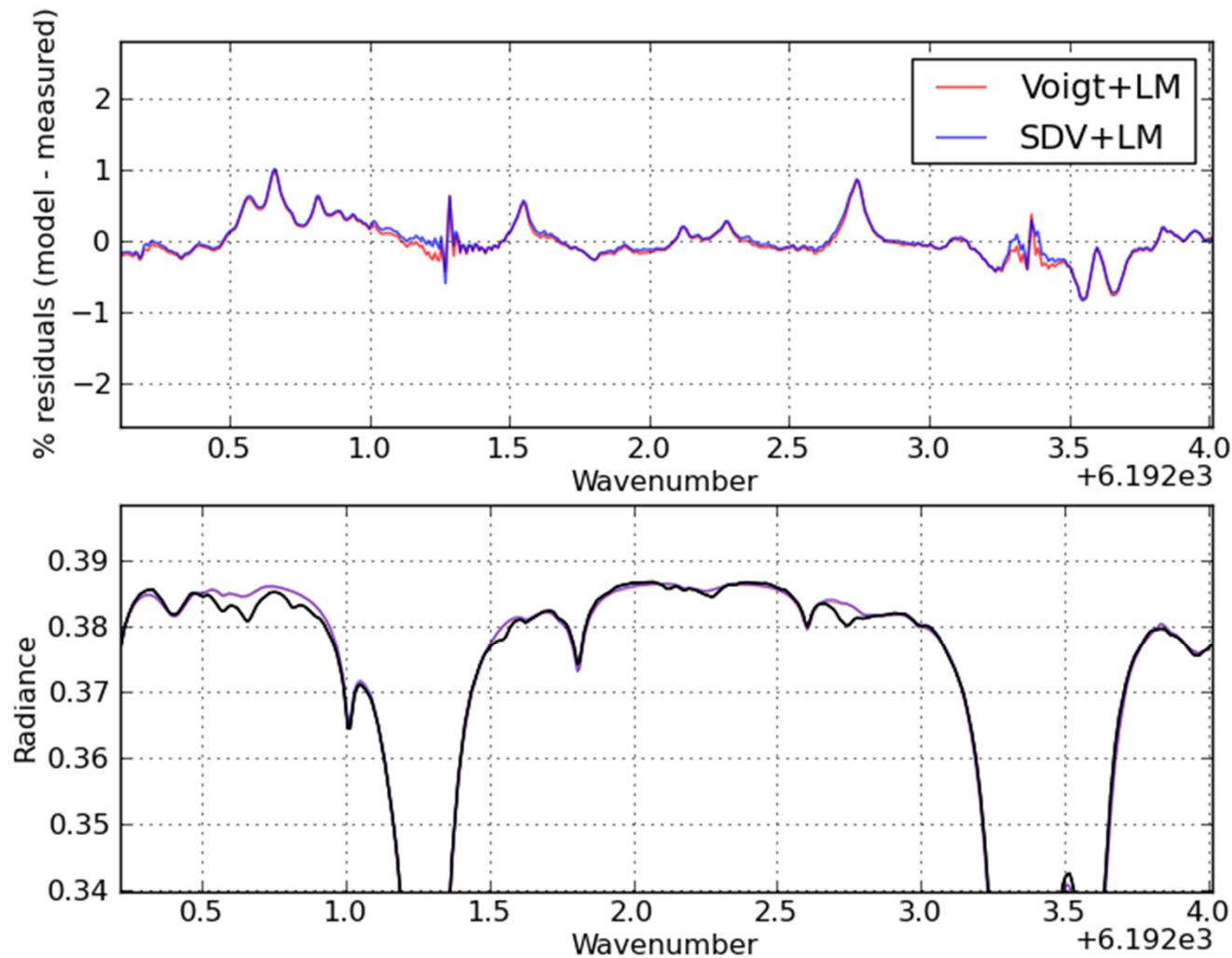
Courtesy Linda R. Brown

# Improving H<sub>2</sub>O intensities

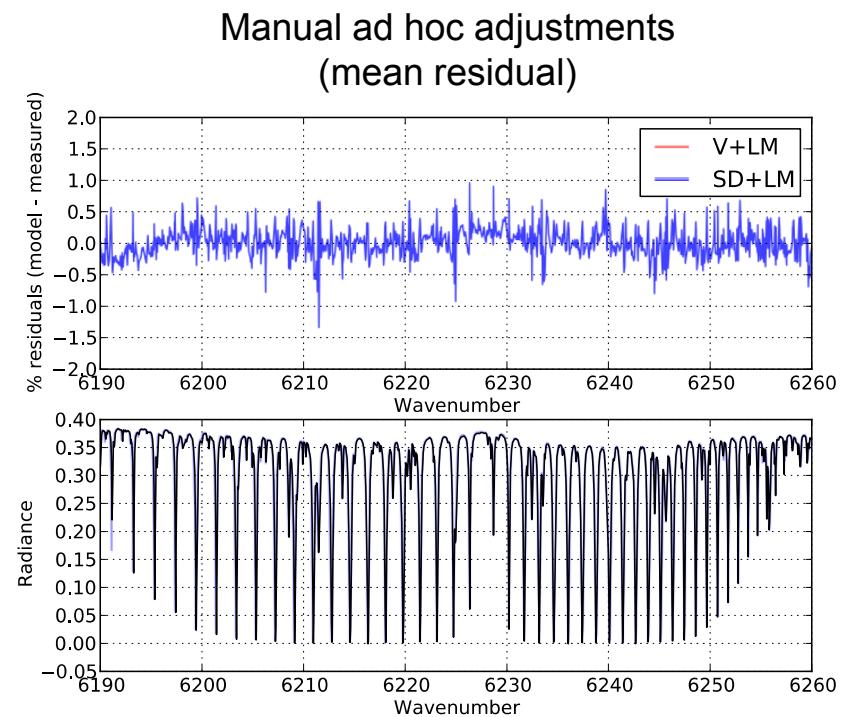
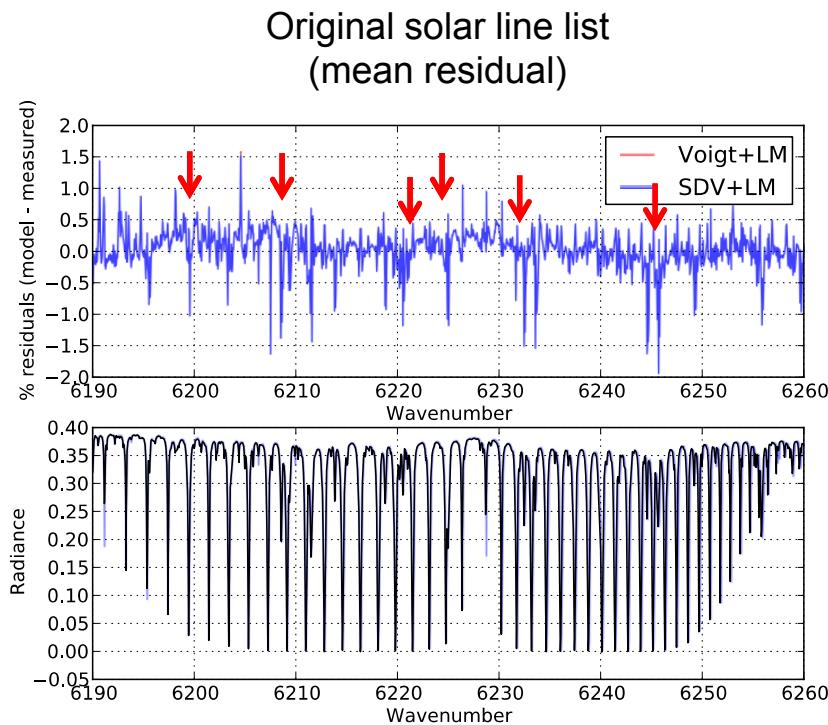


Work in progress,  
courtesy Lorenzo  
Lodi and Jonathan  
Tennyson from  
UCL, Iouli Gordon  
from SAO, Yibo  
Jiang from JPL

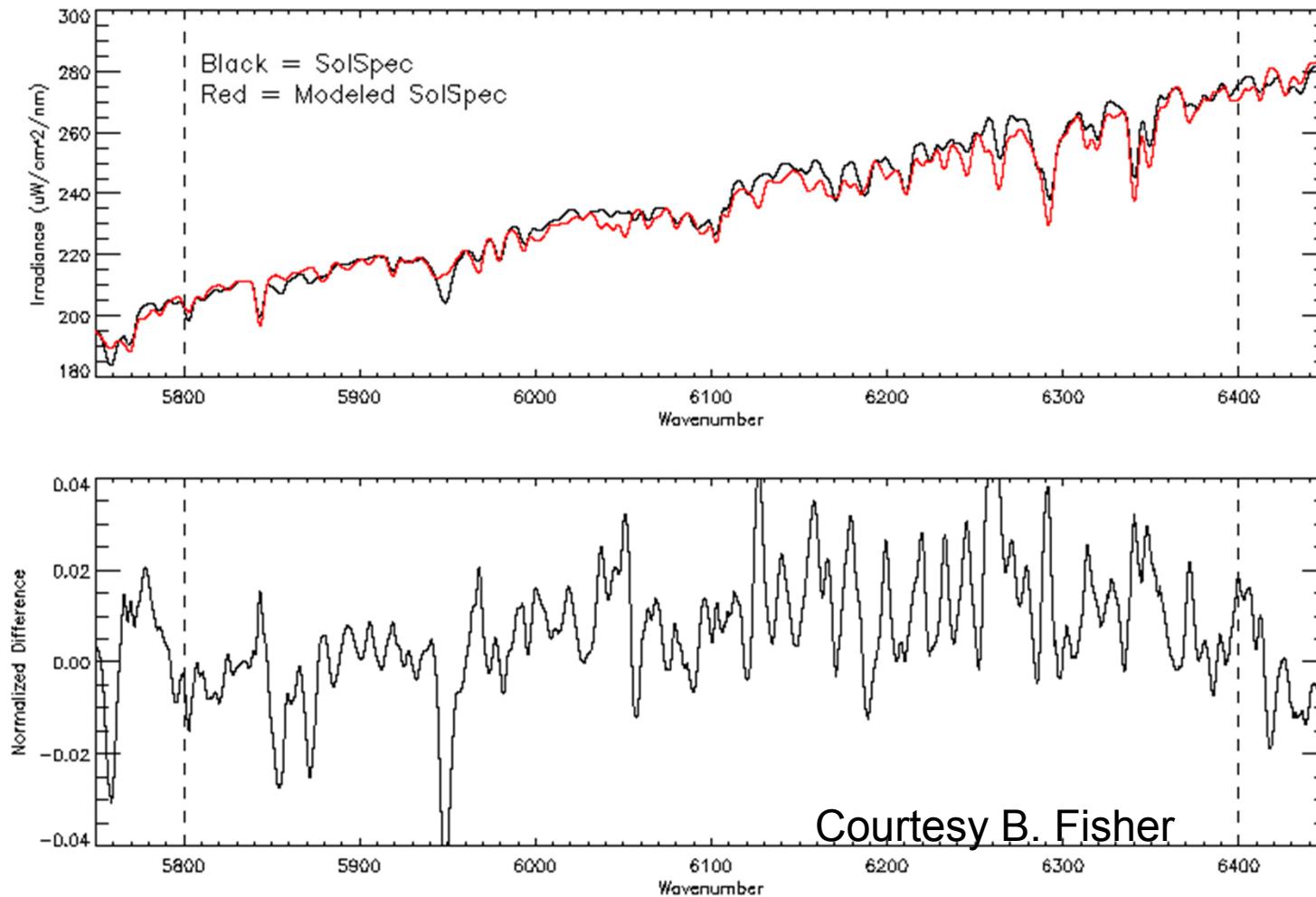
# Current challenges: missing CH<sub>4</sub> lines



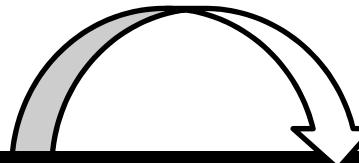
# Current challenges: Solar lines



# Current challenges: Solar continuum



# Moving to v4.1



ABSCO Tables	V4.0	V4.1
<b>4850cm<sup>-1</sup> H<sub>2</sub>O</b>	<b>Line parameters</b>	HITRAN 2008
<b>4850cm<sup>-1</sup> CO<sub>2</sub></b>	<b>Line shape</b>	Speed dependent profile [Benner/Devi] Minor isotopes via Toth et al.
	<b>mixing</b>	Nearest neighbor via multi-spectrum fits [Benner/Devi]
<b>6200cm<sup>-1</sup> CO<sub>2</sub></b>	<b>Line shape</b>	Speed dependent profile [Benner/Devi]
	<b>mixing</b>	Nearest neighbor via multi-spectrum fits [Benner/Devi]
<b>13200cm<sup>-1</sup> O<sub>2</sub></b>	<b>Line shape</b>	Voigt
	<b>mixing</b>	First-order
	<b>rescaling</b>	rescaled to match <i>a priori</i> surface pressure

# Discussion

- Recent improvements are a step in the right direction
- Radiometric accuracies are not yet to the desired 0.1% level, and some systematic errors remain
- New measurements (CRDS, etc) can better constrain line shapes
- Major priorities:
  - The A Band
  - H<sub>2</sub>O broadening (for which we'll need accurate H<sub>2</sub>O retrievals)

# EXTRA SLIDES



# Table construction process, v4.0

